(10) 1. A long line of charge with charge per unit length $\lambda_1$ is located on the x-axis and another long line of charge with charge per unit length $\lambda_2$ is located on the y-axis with their centers crossing at the origin. In what direction is the electric field at point $z = +a$ on the z-axis if all charge is positive?
   a. +z direction; b. -z direction; c. halfway between the x and y direction; d. all directions are possible parallel to the x-y plane.
   Answer: ___

(10) 2. Three equal charges are located at the corners of an equilateral triangle. If the length of the sides of the triangle are doubled and each of the charges is doubled, the the resulting force on each of the charges
   a. is halved; b. stays the same; c. doubles; d. changes by a factor of 1.414.
   Answer: ___
10. 3. An electron, originally at rest, is subjected to an electric field of magnitude $2.5 \times 10^5$ N/C for a distance of 1.0 cm. What is the resulting KE of the electron?

\[ \begin{align*}
   F &= 9E = (1.6 \times 10^{-19} \text{ C}) (2.5 \times 10^5 \text{ N/C}) \\
   &= 4 \times 10^{-14} \text{ N} \\
   KE &= W = Fd = (4 \times 10^{-14} \text{ N})(1 \times 10^{-2} \text{ m}) \\
   &= 4 \times 10^{-16} \text{ J}
\end{align*} \]

Answer: c. $4.0 \times 10^{-16} \text{ J}$

10. 4. The electric field at all points on a closed surface is 225 N/C outwards. If the area of the surface is 6.3 m$^2$, what is the net charge enclosed inside the surface?

\[ \begin{align*}
   \oint \mathbf{E} \cdot d\mathbf{A} &= \frac{Q}{\varepsilon_0} \\
   \oint \mathbf{E} \cdot d\mathbf{A} &= \varepsilon_0 \oint \mathbf{E} \cdot d\mathbf{A} \\
   &= \varepsilon_0 \mathbf{E} \cdot \mathbf{A} \\
   &= \varepsilon_0 (8.86 \times 10^{-12}) (225 \text{ N/C}) (6.3 \text{ m}^2) \\
   &= 1.25 \times 10^{-8} \text{ C} = 12.5 \text{ nC}
\end{align*} \]

Answer: c. 12.5 nC

10. 5. A charge of 1.5 $\mu$C is located at (0,0) and a charge of 2.1 $\mu$C is located at (4m,0). What is the potential at (4m,3m)?

\[ \begin{align*}
   V &= k \frac{1.5 \times 10^{-6} \text{ C}}{5\text{ m}} + k \frac{2.1 \times 10^{-6} \text{ C}}{3\text{ m}} \\
   &= 9 \times 10^9 (0.3 \times 10^{-6} \text{ C} + 0.7 \times 10^{-6}) \\
   &= 9 \times 10^3 \text{ V}
\end{align*} \]

Answer: d. $9 \times 10^3 \text{ V}$
Two parallel flat planes of positive charge are separated by a distance \( d \). Plane #1 has a charge density \( \sigma_1 \) and plane #2 has a charge density \( \sigma_2 \) where \( \sigma_1 > \sigma_2 \). Calculate the magnitude of the electric field in the region outside the planes.

\[
E = E_1 + E_2
\]

\[
E = \frac{\sigma_1}{2\varepsilon_0} + \frac{\sigma_2}{2\varepsilon_0}
\]

\[
E = \frac{\sigma_1 + \sigma_2}{2\varepsilon_0}
\]

\[
\sigma_1 > \sigma_2
\]
7. A long solid non-conducting cylinder is enclosed in a long hollow cylinder as shown. Each cylinder has charge per unit volume \( \rho = 10^3 \text{ C/m}^3 \). Find the electric field at a distance \( r \) from the center axis where \( r < \alpha \). (Ignore \( I \))

\[
\int_{\text{cyl}} E \cdot dA = \frac{\rho \pi r^2 \Delta r}{\varepsilon_0}
\]

\[
\int_{\text{cyl}} E \cdot dA = \frac{\rho \pi \alpha^2}{2 \varepsilon_0}
\]

\[
E(2\pi \alpha l) = \frac{\rho \pi \alpha^2}{2 \varepsilon_0} = \frac{\pi^2 \Delta \rho}{\varepsilon_0}
\]

\[
E = \frac{\rho \alpha}{2 \varepsilon_0}
\]
7. A long solid non-conducting cylinder is enclosed in a long hollow cylinder as shown. Each cylinder has charge per unit volume \( \rho = 10^3 \text{ C/m}^3 \). Find the electric field at a distance \( r \) from the center axis where \( b < r < c \). (Ignore I)

\[
\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\text{en}}}{\varepsilon_0}
\]

\[
\int_{\text{end}} \mathbf{E} \cdot d\mathbf{A} + \int_{\text{cyl}} \mathbf{E} \cdot d\mathbf{A} + \int_{\text{end}} \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\text{en}}}{\varepsilon_0}
\]

\( \mathbf{E} \cdot d\mathbf{A} = 0 \quad \mathbf{E} \cdot d\mathbf{A} = 0 \)

\[
E \int 2\pi r dl = \frac{q_{\text{en}}}{\varepsilon_0} = \frac{\pi \rho l [a^2 - b^2 + r^2]}{\varepsilon_0}
\]

\[
E = \frac{\rho}{2\varepsilon_0} \frac{(a^2 - b^2) + r^2}{r}
\]